RLEP2 – Measurement Team – Dust Subcommittee

Overview:

1. Characterize the reactivity of surface regolith.
2. Measure the physical properties of surface dust deposition.
3. Measure the near-surface electrical potential distribution.
4. Characterize the lunar regolith PSD, shape, color, and image ice/frost.*
5. Measure accrued potential differences: prevention of ESD damage.

What is not covered*:

1. Characterization of the chemical composition of lunar surface regolith.
2. Identification of the presence and form of hydrogen in lunar surface regolith.
3. Measurement of the lunar regolith temperature.
4. Long range imaging of the lunar terrain (i.e. “hand lens” or “tourist mode”).

* stated ISRU requirements

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Requirement I: Characterize the reactivity of surface regolith.

Justification:
i) Significantly enhanced cytotoxicity observed terrestrially for certain surface reactive materials.
ii) Lunar environment (e.g. high solar UV flux, lack of collisional quenching, continuous meteoric and cosmic ray bombardment) favorable for production of surface reactive states.
iii) Prior Apollo experience (astronauts' perception of distinct smell upon re-entering LEM after surface EVAs).

Candidate measurement technique: Electron Paramagnetic Resonance (EPR).

Comments:
i) EPR appropriate for quantifying density of surface radical states.
ii) However, existence of surface radicals shown to be necessary but not sufficient indicator of enhanced cytotoxicity (all materials with equivalent surface radical populations do not exhibit this property) => other mechanisms and mediating conditions may be important.
iii) Other mechanisms and the associated diagnostics are likely to be proposed.
iv) Identified particulate size range for human respiratory health effects: 20 nm – 20 microns. 20 nm – 200 nm particularly problematic: interstitial penetration range. Correlation of regolith composition and structure w/size makes presorting by size desirable.
v) EPR: possible flight instrument: 20 x 20 x 15 cm; 5 Kg nom; 6.5 W; currently low TRL.
vi) All potential instrument candidates likely to require active sample acquisition (e.g. arm, scoop, or other method for material transport).

Requirement II: Measure the physical properties of surface dust deposition.

Justification: i) Observations from Apollo indicate significant deposition of dust on surfaces.

ii) Associated observations indicate surface materials can be problematic: abrasion, degradation and failure of mechanical components and seals, alteration of thermal emissivities.

iii) Dust as a liability emphasizes perturbation, transport, deposition, and adhesion to surfaces (as opposed to more fundamental interest in levitation phenomena).

Candidate measurement technique: Surface detection of particulate number density and PSD.

Comments: i) Can readily augment surface detection capability to determine other useful dust properties:

- Electrical charge state.
- Magnetic susceptibility.
- Deposition and properties of naturally levitated dust.
- Effectiveness of simple abatement strategies.

ii) Technique capable of accessing nominal range of interest (10's of nm – 100's of microns)

- Practical upper bound ≈ 20 microns. Larger sizes: gravitational forces dominate electrostatic forces.

iii) Possible flight instrument: 20 x 20 x 10 cm; < 2 Kg; < 5 W (peak); relatively high TRL: 5 – 6.

iv) Sample acquisition: Must delineate appropriate method for perturbing surface regolith, and proximity to collection surface.

Requirement III: Measure the near-surface electrical potential distribution.

Justification: i) Transport of dust (particulates ~ 20 microns or less) dominated by electrostatic forces.

ii) Associated effect of temporal evolution of near-surface potential: solar illumination and inclination; magnetotail of Earth, etc.

Candidate measurement technique: Langmuir probe.

Comments: i) Spatial msmt's. at multiple heights required to determine form and extent of potential field (2 minimum).

ii) Probe(s) require shielding distance of ≈ characteristic dimension of lander.

iii) Lowest msm't.: < 10 cm from surface. Upper msm't.: order of 1 M above surface.
- Possibility of locating one or more probes on mast.

iv) Threshold sensitivity: 0.1V; max. range: 100 V (possibly bipolar depending on choice of landing site).

v) Possible flight instrument: 20 x 20 x 10 cm; < 3 Kg; < 2 W; high TRL: 8 - 9.

Requirement IV: Characterize the lunar regolith PSD, shape, color, and image ice/frost. (requirement traceability: ISRU)

Justification: i) Properties required to correlate resource yield with physical nature of host material.

Candidate measurement technique: Microscopic imaging.

Comments: i) Assessment of color (or possibly spectrally dependent reflectivity) requires appropriate combination of illumination and/or filtering, dispersion, etc.

ii) Stated nominal resolution: 3 microns; minimum FOV: 1.5 mm.

iii) Possible flight instrument: 400 cm^3; < 1 Kg; 0.5 W; relatively high TRL: 7, including dispersive detection capability.

iv) Sample acquisition: must delineate requirement for proximity to provisions for processing and other msmt's. (chem. comp. of regolith and/or characterization of volatiles).

• Likely to affect required optical working distance.

Requirement V: Measure accrued potential differences: prevention of ESD damage.

Justification: i) Modern electronics are highly prone to ESD damage.
ii) No flight rules presently exist relative to either design or ops.

Candidate measurement technique: Contact potential probe

Comments:
i) Simple configuration to measure accrued potential between relative objects.
ii) Capable of assessing mechanisms of tribocharging and/or natural transport occurring within planetary sheath.
iii) Possible flight instrument: 10 x 210 x 5 cm; < 1 Kg; < 1 W; currently high TRL: 9.
iv) Data acquisition mode: Could implement via interaction between rover/lander, or geotech. probe vs. rover or lander.